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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte NATHAN S. LEWIS,
CAROL LEWIS, ROBERT GRUBBS, and
GREGORY ALLEN SOTZING

Appeal 2009-10154
Application 09/409,644
Technology Center 1700

Heard: 10 December 2009
Decided: February 24, 2010

Before EDWARD C. KIMLIN, CHARLES F. WARREN, and
MARK NAGUMO, *Administrative Patent Judges*.

NAGUMO, *Administrative Patent Judge*.

DECISION ON APPEAL

A. Introduction^{1, 2}

Nathan S. Lewis, Carol Lewis, Robert Grubbs, and Gregory Allen Sotzing (“Lewis”) timely appeal under 35 U.S.C. § 134(a) from the final rejection³ of claims 98-110, 112-123, and 126-159.⁴ We have jurisdiction under 35 U.S.C. § 6. We AFFIRM, but denominate our reasoning as a new ground of rejection.

The subject matter on appeal relates to chemical sensors said to be particularly useful as “analogs of the mammalian olfactory system” (Spec. 1, l. 22), or, colloquially, as an “electronic nose” (*id.* at 6, l. 21). Prior art sensors are said to need dramatically improved detection sensitivity, especially towards biogenic amines and thiols (*id.* at 4, ll. 8-12), in order to mimic the human nose for such uses as monitoring food freshness or identifying disease states (*id.* at 5, ll. 2-7).

The 644 Specification describes sensors based on a variety of “chemiresistor elements” that are said to “yield a rapid, low-power,

¹ Application 09/409,644, *Conductive Organic Sensors, Arrays and Methods of Use*, filed 1 October 1999, claiming the benefit of provisional applications filed 2 October 1998 and 9 July 1999. The specification is referred to as the “644 Specification,” and is cited as “Spec.” The real parties in interest are listed as the California Institute of Technology, and Carol Lewis. (Supplemental Appeal Brief, filed 13 November 2006 (“Br.”), 2.)

² The Official Transcript of the hearing held on 10 December 2009, is cited as “TR.”

³ Office action mailed 25 January 2005 (cited as “OA”).

⁴ Remaining pending claims 50-72 and 85-90 have been withdrawn from consideration and are not before us.

dc electrical signal in response to the analyte of interest.” (Spec. 7, ll. 10-13.) The sensors are said to comprise, generally, “an electrically conductive organic material and a compositionally different conductive material” (*id.* at 12, ll. 14-15) disposed in different regions between two measuring electrodes (*id.* at 25, ll. 11-14).

According to the 644 Specification, as “the [sensor] material absorbs, adsorbs or imbibes an analyte” (Spec. 26, ll. 1-2), it is thought that “the dynamic aggregate resistance provided by these gaps in a given resistor [, e.g., between regions of the compositionally different conductive material,] is a function of analyte permeation of the conductive organic regions of the material” (*id.* at ll. 2-5). Thus, choice of the two distinct materials enables fine tuning of the response of a given sensor to particular analytes based on the degree to which an analyte enters the organic regions of the sensing element. The 644 Specification teaches that a “detector [is] operatively associated with the sensor, for measuring the response of the sensor.” (*Id.* at 12, ll. 17-18.) In various embodiments, the detectors are said to be “optimized to detect a member selected from the group consisting of electromagnetic energy, optical properties, resistance, capacitance, inductance, impedance and combinations thereof.” (*Id.* at 13, ll. 10-14.) Ultimately, in an “electronic nose,” a large number of these sensors can be combined with each other and with other sensors in arrays to provide high degrees of resolution to distinguish various analytes. (*Id.* at 59, l. 21, to 60, l. 15.)

Representative Claim 98 is reproduced from the Claims Appendix to the Principal Brief on Appeal:

98. A sensor, comprising:
- at least two conductive leads;
 - a sensing area comprising
 - alternating regions of*
 - a conductive organic material and
 - a conductive material compositionally different than the conductive organic material
 - disposed between, and in contact with, the at least two conductive leads,
 - wherein the sensing area is in *direct contact* with a vapor comprising an analyte to be detected,
 - wherein the compositionally different conductive material is selected from the group consisting of an inorganic conductor, a carbon black, and a mixed inorganic/organic conductor,
 - wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, a superconductor, or a combination thereof and
 - wherein the inorganic conductor has an electrical conductivity that decreases as the temperature increase[s]; and
 - an apparatus in electrical communication with the conductive leads for *detecting a change in the sensing area* between the at least two conductive leads when contacted with an analyte.

(Claims App., Br. 40; paragraphing, indentation, and emphasis added.)

Independent claims 104, 105, and 106 cover a sensor. Independent claims 108, 126, and 127 cover a sensor array. Independent claim 128 covers a “sensor array system,” while independent claims 148 and 152 each cover a “system” of sensors. Claims 114 and 116, which depend from claim 108, and claims 136 and 138, which depend from claim 128, require temperature control of at least one sensor. Claim 158 depends from claim 152 and requires the presence of at least one of a list of distinct kinds of sensors in addition to a sensor similar to the sensor recited in claim 98. A table outlining the major limitations of the independent claims is presented at 22, *infra*.

The Examiner has maintained the following grounds of rejection:⁵

A. Claims 98-110, 112, 113, 115, 117-123, 126-135, 137, 139-157, and 159 stand rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson,⁶ Barisci,⁷ and any of Casella,⁸ Li,⁹ Thackeray,¹⁰ Yamato,¹¹ Wampler,¹² Naarmann,¹³ or Sakaguchi.¹⁴

⁵ Supplemental Examiner’s Answer mailed 3 October 2008. (“Ans.”). Rejections under 35 U.S.C. § 112(2), an obviousness double patenting rejection, and rejections based on the Stetter and on the DeLacy Costello references have been withdrawn. (Ans. 4.) The order of the alternative secondary references has been altered slightly to group them by related subject matter.

⁶ Timothy David Gibson et al., *Odour Sensor*, WO 9607901A1 (1996).

⁷ J.N. Barisci et al., *Conducting Polymer Sensors*, 4 TRIP 307 (1996).

⁸ Innocenzo G. Casella et al., *Copper Dispersed into Polyaniline Films as an Amperometric Sensor in Alkaline Solutions of Amino Acids and Polyhydric Compounds*, 335 Anal. Chim. Acta 335 (1996).

⁹ H. Li et al., 369 Mat. Res. Soc. Symp. Proc. VI 581 (1995).

B. Claims 114, 116, 136, 138, and 158 stand rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and any of Casella, Li, Thackeray, Yamato, Wampler, Naarmann, or Sakaguchi, and any of Breheret,¹⁵ Mifsud,¹⁶ Moy,¹⁷ or Persaud.¹⁸

We base our Decision on the rejection mailed 25 January 2005, the Brief filed 13 November 2006, the Examiner's Answer mailed 3 October 2007, and the Reply filed 22 October 2007.

¹⁰ James W. Thackeray and Mark S. Wrighton, *Chemically Responsive Microelectrochemical Devices Based on Platinized Poly(3-methylthiophene): Variation in Conductivity with Variation in Hydrogen, Oxygen, or pH in Aqueous solution*, 90 J. Phys. Chem. 6674 (1986).

¹¹ Hitoshi Yamato et al., 87 Synthetic Metals 231 (1997).

¹² Wesley A. Wampler et al., *Composites of Polypyrrole and Carbon Black: Part III. Chemical Synthesis and Characterization*, 10 J. Mater. Res. 1811 (1995).

¹³ H. Naarmann et al., *Electrically Conductive Polymers from Polyheterocyclic Compounds with Derivatives of Tetrathiafulvalene as Counterions, Their Preparation and Their Use*, DE 37 28 452 (1989) (USPTO translation).

¹⁴ M. Sakaguchi et al., JP 0402958 (1992).

¹⁵ S. Breheret et al., 95 Bioflavour 103 (1995).

¹⁶ Jean Christophe Mifsud and L. Moy, *Methods and Devices for the Detection of Odorous Substances and Applications*, U.S. Patent 5,801,297 (1998), used, without objection, as a translation of WO 95/08113 (1995), which is also relied on as a basis of rejection.

¹⁷ L. Moy et al., 95 Bioflavour 55 (1995).

¹⁸ Krishna Chandra Persaud and Paolo Pelosi, WO 86/01599 (1986).

Briefly, the Examiner relies on Gibson for descriptions of a gas sensor having the required structures and functions, including conducting polymers and blends of conducting polymers between the electrodes, but for the alternating regions of a compositionally different conductive material of the required type. The Examiner relies on the group of references cited in the alternative in Rejection A (hereinafter, “alternative secondary references”) as evidence of particular instances of conductive polymers containing metal particles (Casella, Li, Thackeray, Yamato), carbon black (Wampler), organic anions (Naarmann), and organic metal complexes (Sakaguchi), all of which, the Examiner finds, are useful in sensors. According to the Examiner, motivation to combine the references is provided by Barisci, which reviews sensors based on conductive polymers. The Examiner finds that Barisci teaches that conductive polymers have been found to be useful in both conductimetric sensors and amperometric sensors due to the sensitivity of conductive polymers to the chemical environment in which they are placed.¹⁹ The Examiner concludes that a person having ordinary skill in the art would have expected the advantages of the conductive polymer composites taught as sensing electrode materials by the polymer references to be obtained in when substituted for the conductive polymers described by Gibson.

¹⁹ Conductimetric sensors measure changes in the conductivity or, equivalently, the resistivity, of the conductive polymer upon exposure to an analyte. Amperometric sensors measure changes in the current in an electrochemical cell in which the conductive polymer forms part of the sensing electrode.

More particularly, the Examiner maintains that it would have been obvious to incorporate conductors such as carbon black, anions of tetrathiafulvalene, metal particles or metal oxide taught by the secondary references into the conductive organic polymers used in the sensing arrays of Gibson “*because of their sensitivity to known analyte gases or enhanced sensing and/or stability properties* as taught by each of [the references] *compared to sensors made with only the conductive polymers taught by Gibson.*” (OA 15, ll. 1-8; emphasis added.) The Examiner maintains further that Barisci shows that persons having ordinary skill in the art would have recognized and expected “the Gibson conductive polymers to be affected by interactions in a number of sensing formats in a manner that changes the electronic structure and as a result the resistivity of the polymer as shown by Barisci.” (*Id.* at ll. 8-11.)

Lewis contends the Examiner failed to establish a prima facie case of obviousness because the substitution of the electrode materials taught by the polymer references is not a substitution of materials functionally equivalent to the conductive polymeric electrode materials taught by Gibson. The electrode materials taught by the secondary references, Lewis argues, “serve different purposes and are selected based [on] different properties (i.e., the materials of amperometric sensors are selected, in part, because they do not change conductivity).” (Br., sentence bridging 7-8; *id.* at 13-16.) In contrast, Lewis urges, materials for conductimetric sensors, such as those taught by Gibson, are selected based on their ability to change conductivity in response to an analyte. (Br. 8; *id.* at 13-16.)

In response to Lewis's arguments, the Examiner argues further, quoting Barisci at 307 (Ans. 20), that "[i]t is clear that the electrical properties of these materials [conducting polymers] are sensitive to both the material composition and the environment in which they are placed." (*Id.* at 21, ll. 1-2.) The Examiner concludes that "one of ordinary skill in the art would have recognized commonality between the properties of the conductive polymers and the ability to measure a change in the properties of the conductive polymers by the two measurement techniques." (*Id.* at ll. 20-23.) The critical fact, in the Examiner's view, is that in both conductimetric and amperometric sensors, "the interaction with the environment causes change in the electrical properties." (*Id.* at ll. 24-25.) The Examiner emphasizes that "it is the replacement of the conducting polymer compositions of Gibson with those of the secondary references above that the examiner is urging to be obvious in view of the teaching of the applied art." (*Id.* at ll. 27-29.)

B. Findings of Fact

Findings of fact throughout this Opinion are supported by a preponderance of the evidence of record.

The 644 Specification

1. Most generally, the 644 Specification indicates it is directed towards "sensors having electrical properties that vary according to the presence and concentrations of analytes." (Spec. 1, ll. 15-17.)

2. More particularly, sensors that act “as analogs of the mammalian olfactory system” (Spec. 1, ll. 21-22) or, colloquially, as an “electronic nose” *id.* at 6, l. 22) are of interest.
3. An object of the invention is said to be “to provide a broadly responsive analyte detection sensor array based on a variety of ‘chemiresistor’ elements.” (Spec. 7, ll. 8-10.)
4. Such sensors are said to be simply prepared and to “yield a rapid, low-power, dc electrical signal in response to the analyte of interest.” (Spec. 7, ll. 10-13; see also *id.* at 12, ll. 12-17.)
5. A detector is “operatively associated with the sensor, for measuring the response of the sensor.” (Spec. 12, ll. 17-18.)
6. According to the 644 Specification, “The detector or measuring device is optimized to detect a member selected from the group consisting of electromagnetic energy, optical properties, resistance, capacitance, inductance, impedance and combinations thereof.” (Spec. 13, ll. 10-13.)
7. The 644 Specification teaches that “[a]t least one sensor in the array is composed of a material comprising regions of an organic electrical conductor with regions of a compositionally dissimilar material that is an electrical conductor.” (Spec. 25, ll. 8-11.)
8. Conductors are said to “include, for example those having a positive temperature coefficient of resistance” (Spec. 27, l. 21 to 28, l. 1), i.e., the resistance increases (equivalently, the electrical conductance decreases) as the temperature increases (*id.* at 34, ll. 12-14).

9. In contrast, the 644 Specification characterizes semiconductors as “materials whose electrical conductivity increases as the temperature increases.” (Spec. 34, ll. 10-12.)

10. More specifically, the 644 Specification teaches that
the conducting region can be anything that can carry
electrons from atom to atom, including, but not limited to, a
material, a particle, a metal, a polymer, a substrate, an ion, an
alloy, an organic material, (e.g., carbon, graphite, etc.) an
inorganic material, a biomaterial, a solid, a liquid, a gas or
regions thereof.

(Spec. 28, l. 16, to 29, l. 5.)

11. In the words of the 644 Specification, “[t]he resistor comprises a plurality of alternating regions of differing compositions and therefore differing conductivity transverse to the electrical path between the conductive leads.” (Spec. 25, ll. 12-14.)

12. According to the 644 Specification, such sensors can be fabricated by blending the two conductive materials. (Spec. 25, ll. 14-16.)

13. More specifically, the chemiresistors are said to be fabricated by solution casting, when both conductors are soluble; by suspension casting, when one conductor is soluble and the other is not; and by mechanical mixing, e.g., by ball milling, when neither is soluble in a solvent. (Spec. 38, l. 5, to 41, l. 14.)

14. An example of a chemiresistor of the invention is said to comprise a “dispersion of particulate conductive material in a region of conductive organic material,” in which “the regions separating the particles provide

changes in conductance relative to the conductance of the particles themselves.” (Spec. 25, ll. 17-20.)

15. The 644 Specification teaches that “[t]he gaps of different conductance arising from the organic conductive material ranges in path length from about 10 to 1,000 angstroms, usually on the order of 100 angstroms.” (Spec. 25, ll. 20-23.)

16. According to the 644 Specification, in such a material, “[t]he gaps of different conductance arising from the organic conductive material range in path length from about 10 to 1,000 angstroms, usually on the order of 100 angstroms.” (Spec. 25, ll. 20-23.)

17. The 644 Specification teaches that “[t]he path length and resistance of a given gap is not constant but rather is believed to change as the material absorbs, adsorbs or imbibes an analyte.”

18. “Accordingly,” the 644 Specification explains, “the dynamic aggregate resistance provided by these gaps in a given resistor is a function of analyte permeation of the conductive organic regions of the material.” (Spec. 26, ll. 2-5.)

19. Insulators, or non-conducting regions, can also be incorporated into the composite “to further manipulate the analyte response properties of the composites.” (Spec. 36, ll. 2-3.)

20. In the words of the 644 Specification, “[p]referably, the signal is an electrical resistance, although it could also be an impedance or other physical property of the material in response to the presence of the analyte in the fluid.” (Spec. 60, ll. 4-6.)

21. In an embodiment, acid-doped polyaniline (partially reduced polyaniline, “emeraldine,” doped with dodecyl benzene sulfonic acid (DBSA) is dissolved in a solvent, sonicated with carbon black (Spec. 72-73, Example A) and cased onto a glass substrate having two gold leads (*id.* at 73-74, Example B).

22. The response of a sensor to “typical solvents” such as methanol, tetrahydrofuran, chloroform, and water (Spec. 76, ll. 22-23) is reported as 0.5 to 5% $\Delta R/R$ at 1% vapor pressure (*id.* at ll. 15-17).

23. In contrast, a sensor reportedly showed a response to butyl amine ranging from 9000% to 90000% $\Delta R/R$ at 0.5% vapor pressure. (Spec. 77, ll. 21-22; Figure 5.)

Gibson

24. Gibson describes an “odour” or “personnel recognition” sensor comprising “a multiplicity of differentially responding chemo-resistor elements.” (Gibson 1, 3d para.)

25. The chemo-resistive elements comprise conductive polymer films, which are monitored for changes in the electronic characteristics, particularly the resistance, impedance, reactance, or capacitance, in response to exposure to gaseous sample. (Gibson 1, 2d para.)

26. Sensors are described as comprising a multiplicity of chemo-resistive elements comprising a plurality of electrodes disposed on a nonconductive substrate, the electrodes overlaid with one or more layers of conductive polymers, and to have different conductive polymers on at least two of the chemoresistive elements. (Gibson 1, paras. 3-6.)

27. Provisions are made to introduce a gaseous sample to the sensors, and for detectors responsive to the signals from the multiplicity of elements.

(Gibson 1, paras. 7-8; 2, 3d full para.)

28. Gibson teaches further that memory and analytical capability may be included in the sensor. (Gibson, 2, 2d full para.)

29. The conductive polymer films are said to include homopolymers, copolymers, and blends of such polymers and copolymers. (Gibson 13, first full para.)

30. Gibson also teaches that the polymers may be treated with various ionic dopants. (Gibson 13, first full para.).

31. Moreover, Gibson teaches that “acidic proteins and enzymes may be incorporated into partially charged conductive films during or post polymerization” in order to provide sensitivity to specific molecules. (Gibson 13, 2d full para.)

C. Discussion

Lewis’s principal argument is that the Examiner erred in finding that the conductive polymers described by the alternative secondary references would have been considered functional equivalents of the conductive polymers used by Gibson in the sensing elements of the conductimetric sensor. Accordingly, in Lewis’s view, the Examiner’s rationale that the advantages taught for the particle-filled conductive polymers would have been expected in the Gibson-type sensor is incorrect. On review of the

rejections and the evidentiary record, we find much merit in Lewis's contentions.

The Examiner relied on eight secondary references that describe at least three major types²⁰ of conductive polymer electrode materials as examples of electrode materials that would have been obvious to substitute as equivalent electrode materials for the electroconductive polymers described by Gibson in conductimetric sensors.

Gibson describes gas sensors having conductive polymers that respond to gases in some way that leads to a change in the electronic characteristics (e.g., resistance, impedance, reactance, or capacitance) of the polymer (Gibson 1, 2d para) which may be doped (*id.* at 3). Gibson teaches further that “copolymers and blends of the above compounds [list of conductive polymers] may be employed” (*id.* at 13, first full para.) and that “[t]he listed polymers may be treated with various ionic dopant molecules incorporated into the conducting films during and post polymerization (*id.*).

As explained in considerable detail by Lewis (Br. 5-6) and not contradicted by the Examiner, the alternative secondary references relate to amperometric sensors. In such sensors, analytes in solution undergo oxidation-reduction (“redox”) reactions on the surfaces of the sensing electrodes, which are components of an electrochemical cell. The reactions result in charge flow across the electrode-solution interface, which can be measured and related to the particular analyte undergoing the reaction. In the first set of references relied on by the Examiner, the electroactive

²⁰ Five of the conductive polymers contain dispersed metal particles, one contains carbon black, and two contain anions or metal complexes that the Examiner finds are electrical conductors.

polymers coated on the electrodes in the sensors contain metal particles that are said to function as catalysts in the redox reactions of analytes on the surface of the electrodes. None of Casella (polyaniline films containing dispersed copper particles), Li (polyaniline films containing dispersed palladium particles), Thackeray (poly(3-methylthiophene) films containing dispersed platinum particles), or Yamato (polypyrrole/sulfated poly(β -hydroxyether) films containing dispersed palladium particles) teach sensitivity to or detection of analytes in the vapor phase.²¹ Sakaguchi describes gas sensors based on redox electrodes comprising a resin, a conductive resin, and an organic metal complex. (*Id.* at 5, first para.; OA 13; Ans. 15.) Naarmann (conductive copolymers doped with derivatives of tetrathiafulvene as conducting salts; Naarmann at 6) and Wampler (polypyrrole doped with carbon black) refer to sensors generically, but provide no details.

Lewis explains, and again, the Examiner does not contest, that conductimetric sensors, such as those described by Gibson, function in chemically and physically distinct ways from amperometric electrochemical sensors. (Br. 4-6.) Thus, Lewis argues, the Examiner has not established any basis for the alleged expectation that the sensitivity to known analyte gases or enhanced sensing or stability taught by the alternative secondary references for amperometric electrochemical sensors would carry over to the conductimetric sensors taught by Gibson. In Lewis's words, "the Examiner is substituting materials that serve different purposes and are selected based

²¹ The "gases" O₂ and H₂ detected by Thackeray are dissolved in the aqueous solution: they are not in the vapor phase.

upon different properties (i.e., the materials of amperometric sensors are selected, in part, because they do not change conductivity).” (Br., para. bridging 7-8.)

The weight of the evidence of record, as argued by Lewis, indicates that the mechanisms of action and sensitivity of the two classes of sensors differ. The mere fact, though substantiated by Barisci, that electrodes in both kinds of sensors may be sensitive to perturbations of their composition or of the environment does not, without more, establish a reasonable expectation that an enhancement obtained in one sensor will also be obtained in the other. Absent a similar mechanism of action, why would a particle selected for catalytic activity in an amperometric sensor have been expected to promote sensitivity by changing conductance in a conductimetric sensor? Similarly, the Examiner has not explained why the alleged increase in stability found in three-electrode amperometric sensors would have been expected in two-electrode conductimetric sensors, which function in a different way. Nor has the Examiner shown that the alleged advantages described by Sakaguchi, Naarmann, or Wampler would have been expected when using the corresponding doped conductive polymers in the gas sensors described by Gibson. In summary, the Examiner has not established that the electrode materials would have been recognized or reasonably expected to be functional equivalents in amperometric sensors and in conductimetric sensors.

We therefore REVERSE Rejection A.

In Rejection B, the Examiner relies on Breheret, Mifsud, Moy, and Persaud, individually, as evidence of the obviousness of further limitations

required by certain dependent claims. The Examiner does not rely on these references to augment or to shore up the rejection of the corresponding independent claims. Accordingly, we also REVERSE Rejection B.

New Ground of Rejection

In the following, we highlight certain teachings of Gibson that were mentioned by the Examiner, but not emphasized. We focus on Casella, Thackeray, Naarmann, and Wampler as representative alternative secondary references. Because the thrust of the new rejections is substantially different from the thrust of the Examiner's rejections, we denominate our decision a New Ground of Rejection in order to provide Lewis with a full and fair opportunity to respond.

Claims 98, 104-106, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Casella.

Claims 98, 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Thackeray.

Claims 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Naarmann.

Claims 98, 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Wampler.

Claims 114, 116, 136, 138, and 158 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, Mifsud, and any of Casella, Thackeray, Naarmann, or Wampler.

We determine further that nonobviousness of the independent claims has not been established on the basis of unexpected results.

We leave consideration of the further limitations of the dependent claims, which have not been separately argued thus far, to the Examiner and Lewis. We note further that we have generally restricted our attention to issues raised by the arguments of the Examiner and the Appellants. We have done so because our primary role is that of review. We decline to investigate the record and make findings in the first instance that are best made by those who are, by virtue of their previous involvement and specialization, are better positioned to do so.

We emphasize that although the regulations governing appeals to the Board state that “[t]he new ground of rejection is binding upon the examiner unless an amendment or new evidence not previously of record is made which, in the opinion of the examiner, overcomes the new ground of rejection stated in the decision” 37 C.F.R. § 41.50(b)(1), this new ground of rejection is not likely the last word. As our reviewing court has emphasized numerous times, “[a]fter evidence or argument is submitted by the applicant in response, patentability is determined on the *totality* of the record, by a preponderance of evidence with due consideration to persuasiveness of argument.” *In re Oetiker*, 977 F.2d 1443, 1444 (Fed. Cir. 1992) (emphasis added).

The overall basis of the rejection is simply stated. Gibson teaches all the limitations²² of claim 98 regarding the sensor but for the requirement that the sensing area comprise alternating regions of a conductive organic material and a compositionally different conductive material “selected from the group consisting of an inorganic conductor, carbon black, and a mixed inorganic/organic conductor.” In particular, Gibson teaches that “[a] wide range of conductive polymers may be employed” (Gibson at 2, last para.) (including copolymers and blends of copolymers: *id.* at 13, first full para.) in the sensing area of the gas sensors. Moreover, Gibson teaches that “[a] wide range of dopants may be employed” (*id.* at 3, 1st full para.; *id.* at 13, 1st full para.), including ionic dopants (*id.*). Gibson also teaches acidic protein and enzymes may be incorporated into the conductive films to provide sensitivity to specific biological molecules. (*Id.*, 2d full para.) Thus, a person having ordinary skill in polymer-related arts, would have recognized that a variety of additional substances could be added to the base conductive polymer to form a sensing element.

On the basis of these teachings, a person having ordinary skill in the art would have had a reasonable expectation of obtaining a sensor by substituting any electrically conductive polymer otherwise meeting the limitations of the gas sensors taught by Gibson. In other words, absent the disclosure of properties incompatible with properties required by Gibson, such as the presence of large conductive particles that would short the leads,

²² We take as uncontested on the present record that other limitations as to the sample-handling, detection and analysis appearing in the independent claims would have been obvious over the applied references.

or the inability to form a continuous thin film, etc., Gibson teaches that any conductive polymer would have been expected to work.

In particular, the conductive polymers taught by Casella, Thackeray, Naarmann, and Wampler would have been expected to yield working sensors when substituted for the conductive polymers taught by Gibson. That reasonable expectation of success for such subject matter establishes a prima facie case for claims broad enough to encompass such embodiments, *e.g.*, *Velandar v. Garner*, 348 F.3d 1359, 1363 (Fed. Cir. 2003), provided that all other limitations also would have been obvious, as a whole.

The question remains, which claims encompass the obvious subject matter outlined immediately *supra*? The table on the following page summarizes the critical limitations of the independent claims.

TABLE: Major Limitations of the Independent Claims			
Claim	Sensing Area	Different conductive material	Claimed Subject Matter
98	AR	I·O, CB	Sensor
104	AIR	O, I·O	"
105	DR	O, I·O	"
106	AR(pA)	any	"
108	AIR	O, I·O	Sensor Array
126	AIR	O, I·O	"
127	AIR	any	"
128	AIR	O, I·O	Sensor Array System
148	AIR	any	System
152	AIR	O, I·O	"

Key

AR	alternating regions (organic)
AIR	alternating interpenetration regions (organic)
DR	dispersed regions (organic)
pA	polyaniline or emeraldine salt
O	Organic, Organic Complex
I·O	Inorganic, mixed Inorganic/Organic
CB	Carbon Black
app	apparatus

All sensing areas comprise a conductive organic material and a compositionally different conductive material as specified.

Inorganic materials are limited as recited in claim 98, reproduced *supra* at 4.

All claims except claim 127, which uses means-plus-function language, recite an apparatus (claim 152, “detector”) for detecting a change in the sensing area upon exposure to an analyte. The nature of the change is not specified, except in claim 128, which requires an apparatus that measures an electrical change.

When interpreting claims in an application for patent, we must interpret the claims using “the broadest reasonable meaning of the words in their ordinary usage as they would be understood by one of ordinary skill in the art, taking into account whatever enlightenment by way of definitions or otherwise that may be afforded by the written description contained in the applicant’s specification.” *In re Morris*, 127 F.3d 1048, 1054 (Fed. Cir. 1997).

Applying this principle to the terms “alternating regions,” “alternating interpenetrating regions,” and “dispersed regions,” we observe that Lewis has not, in the filed appeal briefs, directed our attention to express definitions of these term in the 644 Specification. The term “alternating regions” often suggests isolation, such that the regions A and B in a structure

. . . ABABABABAB . . .

do not connect with one another. In contrast, the term “alternating interpenetrating regions” often suggests that the A regions are connected and the B regions are connected, like a pair of opposed combs with interpenetrating teeth or the interdigitated electrodes shown in Figure 1 of the 644 Specification. The term “dispersed regions” ordinarily suggests that regions A are not connected to one another and are scattered in an otherwise continuous medium B.

However, the 644 Specification does not distinguish among these possibilities. In the general summary of the invention, compositionally distinct “regions” are described, and the sensor is said to provide “an electrical path through the regions of the organic material and the conductive material. (Spec. 8, ll. 2-3, etc.) In the detailed description, the regions

having different compositions are described as “alternating” and as providing a conductive path having different conductivities “transverse to the electrical path between the conductive leads.” (*Id.* at 25, ll. 11-14.) Strikingly, the preparation of such materials is described to be the result of blending a conductive material into a conductive organic material. (*Id.* at ll. 14-16.) Moreover, according to the 644 Specification, “in a colloid, suspension, or dispersion of particulate conductive material in a region of conductive organic material, the regions separating the particles provide changes in conductance relative to the conductance of the particles themselves.” (*Id.* at ll. 18-20.) Examples of solution casting, suspension casting, and mechanical mixing are provided for cases in which there is a common solvent for both materials, a solvent for only one material or the other, or no solvent for either material, respectively. (*Id.* at 38-41.) The 644 Specification does not appear to describe specific techniques for making the “alternating” and “alternating interpenetration” regions as narrowly described in the preceding paragraph. Thus, it is consistent with the written description to apply a broader reading to the three named regions.

Keeping in mind that we are not writing on a bare slate; that neither Lewis nor the Examiner have found differences among the terms; and that no new matter has been found: we conclude, on the present record, that the terms “alternating regions,” “alternating interpenetrating regions,” and “dispersed regions,” as used in the claims, are synonymous. Should any other interpretation be advanced during further prosecution of these claims, basis in the originally filed 644 Specification should be identified.

We note further that carbon black is described as an organic compound (e.g., Spec. 26, l. 14), and is therefore available as the “different conductive material” not only in claim 98, in which it is specifically recited, but in all the other claims, which either recite an organic different conductive material or do not recite any compositional limitations on the different conductive material.

Finally, we note that the 644 Specification defines a conducting region as “anything that can carry electrons from atom to atom, including, but not limited to, a material, a particle, a metal, a polymer, a substrate, an ion, an alloy, an organic material, (e.g., carbon, graphite, etc.) an inorganic material, a biomaterial, a solid, a liquid, a gas or regions thereof.” (Spec. 28, l. 16 to 29, l. 5.) Indeed, the 644 Specification indicates the electrically conductive organic region “can optionally be a ligand that is attached to a central core making up [a] nanoparticle” (*id.* at 29, ll. 16-18) in a colloid. Thus, the “different conductive material,” in the most general case, can be a very small region in the sensing area of the sensor.

Claims 98, 104-106, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Casella.

We have no difficulty finding that Casella (conductive polyaniline films containing dispersed copper particles) meets the sensing area requirements of the organic conductor and the compositionally different conductive material recited in all of the independent claims.

Claims 98, 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Thackeray.

Thackeray (poly(3-methylthiophene) films containing dispersed platinum particles) is similar to Casella. However, Thackeray does not describe or suggest conductive polyaniline films containing a compositionally different conductive material. Thus, Thackeray, in combination with Gibson and Barisci, does not suggest the alternating regions required by claim 106. The limitations of the other independent claims do not, however, exclude either the organic conductive polymer or the compositionally different conductive material disclosed by either Thackeray.

Claims 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Naarmann.

Naarmann describes conductive electrode materials having a conductive polymer and a conductive anion (tetrathiafulvene) salt. As Lewis points out (Br. 25), Naarmann does not describe an inorganic conductor, a carbon black conductor, or a “mixed inorganic/organic conductor” as required by claim 98. Nor does Naarmann describe polyaniline films, as required by claim 106. However, independent claims 127 and 148 do not limit the conductive organic compound or the different conductive compound in any way, other than that they be compositionally different from one another. Moreover, remaining independent claims 104, 105, 109,

126, 128, and 152 include organic conductors and organic complexes in addition to inorganic conductors and mixed inorganic/organic conductors as the “compositionally different conductive material.” Thus, given the broad scope of the term “organic conductor” (which, in any event, includes “organic complex”), we cannot say the Lewis has shown harmful error in the Examiner’s finding that the tetrathiafulvene salts of Naarmann are conductors meeting the compositionally different conductive material required by claims other than claim 98.

Claims 98, 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Wampler.

Wampler (polypyrrole and carbon black) does not describe polyaniline based electrodes. Thus, claim 106 is not obvious over combinations of Wampler, Gibson, and Barisci. None of the remaining independent claims exclude polypyrrole as the organic conductive material or carbon black as the other conductive material.

As already noted, the “apparatus” limitations of the independent claims have not been argued with particularity as bases for patentability. On the present record, we find such features to be obvious aspects of sensors and sensor systems that are suggested by both Gibson and Barisci.

We conclude that a prima facie case of obviousness, based on a reasonable expectation of successfully substituting conductive polymers with the additional “other conductive materials” taught by the alternative

secondary references, has been established, with the exceptions set forth *supra*.

Claims 114, 116, 136, 138, and 158 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, Mifsud, and any of Casella, Thackeray, Naarmann, or Wampler.

These claims cover two distinct limitations: temperature control of at least one sensor in the sensor array (claims 114, 116, 136, and 138); and the requirement that at least additional one sensor from an enumerated list be included in the claimed system (claim 158). The Examiner has relied on either Mifsud or Breheret as evidence that it would have been obvious to use a named sensor element in combination with sensors elements of claim 152 in an odor sensor, and to control the temperature of a sensor in Gibson's device, as modified by using a composite polymer described in at least one of the alternative secondary references. The Examiner relies on Moy and on Persaud as evidence of the obviousness of combining metal oxide sensors gas with conductive polymer sensors in an odor sensing array system.

Although we rely only on Mifsud, the arguments relating to the additional references are instructive.

Mifsud teaches that semiconductive (metal oxide: Mifsud, col. 7, ll. 47-49) gas sensors 6, conductive polymer gas sensors 7, and surface acoustic wave gas sensors 8 (Mifsud, col. 5, ll. 44-46) are sensitive to the temperature and humidity (*id.* at col. 6, l. 65 to col. 7, l. 1), and that measurements are required to perform comparisons of different odorous substances (*id.* at col. 7, ll. 1-3). (*See* OA 16.) Moreover, Mifsud teaches

that the three kinds of sensors are combined in a single device, either serially (Fig. 1) or in parallel and in series (Fig. 2). (*Id.* at col. 5, ll. 13-19.)

Lewis argues that Mifsud does not cure the defects alleged regarding the Examiner's combination of the teachings of Gibson and the alternative secondary references. (Br. 35.) But there are no deficiencies as to independent claims 108, 128, and 152 in the new ground of rejection. Lewis argues further that Mifsud teaches away from the claimed invention because Mifsud teaches that conductive polymer films are less sensitive than semiconductor gas sensors. (*Id.*) This is not persuasive of harmful error because the alleged superiority of one type of sensor over the other has little if any bearing on Mifsud's teaching that it would have been obvious to combine sensors to take advantage of sensors having different sensitivities. Lewis also argues, and the Examiner does not contest, that the temperature of the semiconductor response is inverse to the limitation on the inorganic conductor that the electrical conductivity decrease as the temperature increases. (*Id.*) This argument is misplaced, however, because that temperature sensitivity is a limitation only of the inorganic conductor that comprises the compositionally different conductive material in the alternating interpenetrating region recited in claim 152. The additional sensors recited in claim 158 are not limited by such a temperature dependence. Moreover, Mifsud also uses surface acoustic wave detectors in combination with conductive polymer detectors. We conclude that it would have been obvious to combine detectors from the list recited in claim 158 with other kinds of detectors to gain the particular sensitivity advantages of each type of detector in a single sensor. Lewis does not address the

obviousness of applying the temperature control taught by Mifsud. We conclude it would have been obvious, based on Mifsud, to provide temperature control of conductive polymer sensors as required by claims 114, 116, 136, and 138, in sensor arrays or systems including sensors obvious over the combined teachings of Gibson and Barisci.

Moy, as applied against claim 158, is largely cumulative with Mifsud, but without temperature control. Persaud does not appear to describe a sensor in the list recited in claim 158. Breheret is somewhat more complicated. According to Breheret, the temperature of the array of five semiconductor gas sensors was controlled. (Breheret 104, cited at OA 15-16.) Breheret also reports that an array of twenty different conducting polymer gas sensors was tested; but Breheret is silent as to temperature control of the conducting polymer gas sensors. We conclude that at best the Examiner's reliance on Breheret for the obviousness of combining plural types of sensors is cumulative with Mifsud, and that Breheret does not advance the Examiner's contention that temperature control of the claimed conductive sensors would have been obvious.

Accordingly, we hold that, in view of the teachings of Mifsud, it would have been obvious to apply temperature control, as required by claims 114, 116, 136, and 138, to alternating interpenetrating electrode sensors obvious in view of the combined teachings of Gibson, Barisci, and any of Casella, Thackeray, Naarmann, or Wampler.

Similarly, we hold that it would have been obvious to combine alternating interpenetrating electrode sensors obvious in view of the combined teachings of Gibson, Barisci, and any of Casella, Thackeray,

Naarmann, or Wampler, with the surface acoustic wave detectors and electrochemical detectors described by Mifsud.

In its Brief (Br. 38-39) and at oral argument (Tr. 10, l. 10; *id.* at 22, ll. 9-22), Lewis argued further that evidence of unexpected results, in particular, the demonstration that the “response [to triethylamine] is orders of magnitude larger than any seen from sensors prepared from insulating polymer-carbon black composite films” (Br. 39, citing Figure 4 [sic: and 5] and Spec. 15, ll. 12-18 [sic: and Spec. 15, l. 19 to 16, l. 2]) should be given weight.

A heightened sensitivity of three- to four-orders of magnitude is indeed impressive. The difficulty with this demonstration is that evidence of unexpected results must be commensurate in scope with the claimed subject matter. *In re Peterson*, 315 F.3d 1325, 1330–31 (Fed. Cir. 2003) (citing additional cases). In the present case, the 644 Specification indicates that a chemical reaction between certain analytes and certain conductive polymers results in structural changes in the polymer that transform the polymer from a conductive state to an insulating state. In the words of the 644 Specification, regarding a particular example, “[t]his mechanism appears to be responsible for the majority of the resistance increase observed upon exposure of the acid-doped emeraldine sensors to amines.” (Spec. 83, l. 19 to 84, l. 1.) The disclosure teaches further that the proposed mechanism for the response of the sensor to more common solvents—i.e., solvents that do not react with the conductive polymer—involves a decrease in conductivity through the carbon black particles. The magnitude of such a

response—0.5% to 5% $\Delta R/R$ at 1% vapor pressure (Spec. 77, ll. 12-17; see also Figure 11a, described at Spec. 87, comparing response to common solvents with the response to butylamine)—is not reported as unexpected.

On the present record, it appears that the very high sensitivities are limited to combinations of sensors based on conductive polymers as the continuous phase with analytes that react chemically with those conductive polymers. Sensitivity to nonreactive analytes such as water or methanol, appears to be ordinary. But none of the independent claims are so limited as to both the sensor and the analyte. On the present record, we conclude that the evidence of unexpected results is inadequate to overcome the prima facie case of obviousness.

At oral argument, Counsel indicated that, following a period of vigorous prosecution, an impasse had been reached and that an appeal was judged necessary to move the case forward, temporarily precluding the introduction of additional evidence. (Tr. 23, ll. 10-18.) The delays reaching this point are unfortunate, particularly so given the as yet unresolved issues remaining in this application. Yet, we hope that certain issues of claim interpretation, particularly as to the scope of the claims, and certain issues regarding the teachings of the references, have been clarified sufficiently to allow further progress towards resolution of this application for patent.

We remind the Examiner and Lewis that although all the independent claims have been rejected, as well as claims subject to Rejection B, we have not considered the remaining dependent claims. We leave the disposition of those claims to the Examiner in the first instance.

We have also not entered new grounds of rejection based on references that we consider essentially cumulative on the present record. This omission is not preclusive; but the Examiner should consider carefully whether another reference raises a distinct issue of patentability before entering yet another rejection of an already rejected claim.

D. Order

We REVERSE the Examiner's rejection of claims 98-110, 112, 113, 115, 117-123, 126-135, 137, 139-157, and 159 under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and any of Casella, Li, Thackeray, Yamato, Wampler, Naarmann, or Sakaguchi.

We REVERSE the Examiner's rejection of claims 114, 116, 136, 138, and 158 stand rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and any of Casella, Li, Thackeray, Yamato, Wampler, Naarmann, or Sakaguchi, and any of Breheret, Mifsud, Moy, or Persaud.

We enter the following New Grounds of Rejection:

Claims 98, 104-106, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Casella.

Claims 98, 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Thackeray.

Claims 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Naarmann.

Claims 98, 104, 105, 108, 126-128, 148, and 152 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, and Wampler.

Claims 114, 116, 136, 138, and 158 are rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Gibson, Barisci, Mifsud, and any of Casella, Thackeray, Naarmann, or Wampler.

This decision contains new grounds of rejection pursuant to 37 C.F.R. § 41.50(b). This section provides that “[a] new ground of rejection... shall not be considered final for judicial review.”

37 C.F.R. § 41.50(b) also provides that the Appellants, WITHIN TWO MONTHS FROM THE DATE OF THE DECISION, must exercise one of the following two options with respect to the new grounds of rejection to avoid termination of the appeal as to the rejected claims:

- (1) Submit an appropriate amendment of the claims so rejected or new evidence relating to the claims so rejected, or both, and have the matter reconsidered by the examiner, in which event the proceeding will be remanded to the examiner. . . .
- (2) Request that the proceeding be reheard under § 41.52 by the Board upon the same record

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a).

AFFIRMED: 37 C.F.R. § 41.50(b)

Appeal 2009-10154
Application 09/409,644

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